

**EXOTIC LADY BEETLE SURVEY IN
NORTHEASTERN UNITED STATES:
HIPPODAMIA VARIEGATA AND *PROPYLEA
QUATUORDECIMPUNCTATA* (COLEOPTERA:
COCCINELLIDAE)¹**

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ABSTRACT: A multistate survey coordinated through the USDA APHIS Cooperative Agricultural Pest Survey (CAPS) Program to detect the exotic coccinellids *Hippodamia variegata* (Goeze) and *Propylea quatuordecimpunctata* (L.) was conducted in the northeastern United States in 1993. We provide 34 new collection records for *H. variegata*. The surveys demonstrated an expanded distribution and defined the leading edge of expansion for *H. variegata* and *P. quatuordecimpunctata* in the northeastern United States. We also provide information on the displacement of native coccinellids by these two exotic species.

Hippodamia variegata (Goeze) and *Propylea quatuordecimpunctata* (L.) are two exotic coccinellids that have recently become established in the northeastern United States. *H. variegata* is a biological control agent that attacks aphid pests in its home range of Eurasia, Africa, and India (Gordon 1987). Michels and Bateman (1986) considered this coccinellid to be useful in helping suppress populations of the greenbug, *Schizaphis graminum* (Rondani), a grain pest in the Plains States. In 1986, the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine (PPQ) mass-produced and released *H. variegata* in midwestern and western states for biological control of the Russian wheat aphid, *Diuraphis noxia* (Mordvilko), a serious pest of small grains. Establishment in the midwestern and western regions was unsuccessful (Flanders et al. 1991, Prokrym et al. 1992).

Gordon (1987) reported that the first established population of *H. variegata* in North America was observed in 1984 near Montreal in eastern Canada. *H. variegata* may have become established through accidental introduction by European vessels in the St. Lawrence Seaway (Gordon 1987, Schaefer and Dysart 1988, Day et al. 1994) or through intentional releases. The USDA released this coccinellid from 1957 to 1983 and 1987 to 1993 in eastern and midwestern states (Gordon 1985, Gordon 1987, Dysart 1988, Flanders 1990, Wheeler 1993). As *H. variegata* had never been intentionally released in Canada, its establishment there was most likely a result of accidental introduction via shipping (Day

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et al. 1994). By 1989, *H. variegata*'s distribution had expanded from Montreal to Ottawa, Canada, and by 1992, Wheeler (1993) reported the first U.S. occurrences from CT, MA, NH, NJ, NY, PA, RI and VT.

Propylea quatuordecimpunctata is also a common aphid predator throughout Europe. The USDA introduced *P. quatuordecimpunctata* in 1968 to help control greenbugs (Rogers et al. 1972). It was reared and released in DE, NJ, OK and WA from 1970 to 1982 (Gordon 1985). Like *H. variegata*, it also was not recovered at these locations (Flanders et al. 1991, Prokrym et al. 1992).

Researchers in the United States and Canada have monitored the expansion of *H. variegata* and *P. quatuordecimpunctata* in North America. Day et al. (1994) and Wheeler (1990) discussed the distributional history of *P. quatuordecimpunctata* in the northeastern United States. Day et al. (1994) described the known distribution for *P. quatuordecimpunctata* using existing collection records for nine northeastern states and information from our survey. Wheeler (1993) reported the establishment of *H. variegata* in eight states, and Hoebeke and Wheeler (1996) built on this effort with new collection records from Canada.

The objectives of this paper are to 1) document information from a coordinated, 11-state survey that employed standardized sampling methods to track exotic coccinellids, specifically *H. variegata* and *P. quatuordecimpunctata*; 2) expand on studies by Wheeler (1993) and Day et al. (1994) by providing the most current distribution of *H. variegata* and *P. quatuordecimpunctata*; 3) note habitat preferences for both beetles; and, 4) provide additional insight on displacement of native coccinellids by exotic species.

METHODS

Cooperators from universities, departments of agriculture, and Cooperative Extension Systems in 11 states (CT, DE, MA, MD, ME, NH, NY, PA, RI, VT, VA) surveyed for *H. variegata* and *P. quatuordecimpunctata* between mid-June and the end of August, 1993 (Table 1). The lead author served as survey coordinator; provided the site-selection protocol, survey methodology, guidelines for specimen identification, and other appropriate references (e.g., Gordon 1985, Gordon and Vandenberg 1991); and prepared the final report. The APHIS Niles

Table 1. Participants in the CAPS Exotic Coccinellid Multistate Survey

CT: Donna Ellis, University of Connecticut

DE: Joanne Whalen, University of Delaware

MA: Craig Hollingsworth, University of Massachusetts

MD: Dick Bean, Charles Staines, Maryland Department of Agriculture

ME: Ron Mack, University of Maine

NH: John Weaver, University of New Hampshire

NY: Janet Knodel, Cornell University

PA: Nancy Hill Richwine, Jim Stimmel, Al Wheeler, Pennsylvania Department of Agriculture

RI: Lisa Tewksbury, University of Rhode Island

VT: Jon Turmel, Vermont Department of Agriculture

VA: Eric Day, Virginia Polytechnic Institute and State University

Plant Protection Center provided reference specimens to the survey participants.

Survey participants selected fields that were greater than three acres; that were planted to alfalfa, clover, vetch or cereals; and which did not receive insecticides for 30 days before sampling. At least one field in each of three counties per state was surveyed biweekly for a total of six visits to each field. Participants timed survey activities to coincide with the highest aphid populations in their state as determined by field observations and personal knowledge. Only adult lady beetles were collected.

Two methods of sweep-net collecting of adult coccinellids were used to provide more information on habitats in the northeastern region where these predators were found. In the first method, participants in ME, NH, NY and VT swept insects from host plants by making 500 sweeps in each of three locations within the same field (1,500 total sweeps per survey site). In the second method, participants in CT, DE, MA, MD, PA, RI and VA combined 100 sweeps in each of four diverse adjacent habitats at one site. It was recommended that participants sample diverse habitats such as agricultural crops (e.g., alfalfa, clover, or vetch fields), weedy field borders and woodland edges.

The unsorted insect material collected from the field was placed in a labeled bag and returned to the state laboratory for sorting. State cooperators examined the coccinellids from each sample for *H. variegata* and *P. quatuordecimpunctata* adults. Suspect coccinellids were sent to the APHIS Niles Center for confirmation of the identification, with voucher specimens retained at Niles.

The participants handled recovery data in several ways. Information on first-of-season captures of *H. variegata* or *P. quatuordecimpunctata* and new state or county records confirmed by the Niles Center were posted via electronic mail to CAPS cooperators. Positive and negative survey data from each participating state were submitted to the CAPS National Agricultural Pest Identification System (NAPIS) database, a national database for the distributions of pest and beneficial species.

RESULTS AND DISCUSSION

State cooperators surveyed for *H. variegata* and *P. quatuordecimpunctata* in 100 counties in the 11-state region during 1993, more than three times the number of survey sites required by the survey protocol. The overwhelming response by the cooperators resulted in far more survey and distribution data collected than had originally been requested.

H. variegata was found in 45 counties (45% of the total counties surveyed), which included 34 new county records, or 76% of the total number of counties where this coccinellid was collected (Table 2). A specimen of *H. variegata* collected from Cumberland County, Maine, in 1991 was discovered in a personal collection (R. Mack, pers. commun., 1993). This specimen represented a

Table 2. First recoveries of *Hippodamia variegata* (Goeze) from the north-eastern United States from 1993 CAPS regional and related surveys.¹

State	County	Date	Collector
Connecticut	Litchfield	09/16/93	D. Ellis
	Middlesex	07/08/93	D. Ellis
Maine ²	New London	06/10/93	D. Ellis
	Androscoggin	09/13/93	R. Mack
	Aroostook	09/07/93	R. Mack
	Franklin	09/16/93	R. Mack
	Hancock	09/02/93	R. Mack
	Kennebec	09/15/93	R. Mack
	Lincoln	09/13/93	R. Mack
	Oxford	09/16/93	R. Mack
	Penobscot	09/10/93	R. Mack
	Piscataquis	09/08/93	R. Mack
	Sagadahoc	09/13/93	R. Mack
Massachusetts	Somerset	09/08/93	R. Mack
	Washington	09/07/93	R. Mack
	Essex	09/07/93	R. Mytkowicz
	Norfolk	07/01/93	R. Mytkowicz
New Hampshire	Plymouth	07/22/93	D. Fernandes
	Hillsborough	08/09/93	S. Reynolds
	Rockingham	09/21/93	S. Reynolds
New Jersey ³	Strafford	08/03/93	J.S. Weaver/S. Reynolds
	Burlington	08/12/93	W. Peasley
	Essex	07/15/93	J. VonderHorst
	Hunterdon	08/04/93	H. Crowley
	Morris	07/12/93	H. Crowley
	Passaic	07/16/93	J. VonderHorst
	Union	07/26/93	J. VonderHorst
New York	Monroe	09/08/93	J. Knodel
	Ontario	08/05/93	J. Knodel
	Seneca	09/22/93	J. Knodel
	Tioga	09/19/93	R. Hoebeke
	Yates	08/06/93	J. Knodel
Pennsylvania	Delaware	08/19/93	R.L. Stewart
	Monroe	08/20/93	R.L. Stewart
	Northhampton	08/16/93	R.L. Stewart
Rhode Island	Newport	09/22/93	L. Tewksbury
	Washington	09/15/93	L. Tewksbury
Vermont	Orange	09/09/93	J. Turnel

¹ *Propylea quatuordecimpunctata* collection records from the CAPS survey reported by Day et al. 1994.

² D. Barry collected the first two *H. variegata* specimens from Maine in Cumberland Co. on 15 July 1991 and York Co. on 25 July 1991. The Cumberland Co. specimen represents the earliest known U.S. collection, although it was reported subsequently to Wheeler (1993). These earlier collection records were uncovered as part of the CAPS regional survey effort.

³ R. Chianese, unpub. data, 1994.

new state record for Maine.

Propylea quatuordecimpunctata was found in 66 counties (66% of the total counties surveyed), with 46 of these occurrences representing new county records. New county records were obtained in 70% of the counties where this beneficial coccinellid was surveyed and found during 1993. Collection records for *P. quatuordecimpunctata* have been reported by Day et al. (1994).

Survey results illustrate the expanding range of both *H. variegata* (Fig. 1) and *P. quatuordecimpunctata* (Fig. 2). Following the CAPS multistate survey in 1993, additional new state and county records for the two species have been collected by many individuals in the northeast region, including most of New Jersey and parts of eastern Pennsylvania and New York (R. Chianese, pers. commun., 1994; A. Wheeler, pers. commun., 1996; Wheeler and Stoops 1996). In New Castle County, Delaware, a single *H. variegata* was collected from alfalfa by J. Tropp in 1994 and a *P. quatuordecimpunctata* adult was collected by W. Day in 1997, representing new state records for these coccinellids (W. Day, unpubl. data, 1997). To date, *H. variegata* and *P. quatuordecimpunctata* have not been collected in Maryland, Virginia, or states west of the survey region. We expect that the coccinellids will continue to expand from their current distribution, however, as recently reported for *H. variegata* by Hoebeke and Wheeler (1996).

Propylea quatuordecimpunctata adults were generally observed earlier in the season (Figs. 3A-3C) and in greater abundance than *H. variegata* (Figs. 4A-4C) during the 1993 survey. *P. quatuordecimpunctata* was found by mid-May in Connecticut (Fig. 3A), early June in Massachusetts (Fig. 3B), and mid-June in Pennsylvania (Fig. 3C) and Rhode Island (Fig. 3A). This coccinellid continued to be collected throughout the summer and early fall in locations where it was present early in the growing season. Although *H. variegata* was collected by mid-June in Connecticut (Fig. 4A) and by late June in New Hampshire (Fig. 4B) and Pennsylvania (Fig. 4C), adults were usually captured during the survey from mid-August through September. In Vermont, *H. variegata* was found only in September on flowering alfalfa (Ellis and Adams 1993, J. Turmel, pers. commun., 1993). With a similar response of *H. variegata* and *P. quatuordecimpunctata* occurring across all states, researchers are encouraged to time future surveys for these coccinellids during peak abundance. The seasonal occurrences of *H. variegata* and *P. quatuordecimpunctata* were fairly consistent from state to state. Lack of collection data from a particular location surveyed during a period when the coccinellids have previously been found in other northeastern states (Figs. 1 and 2) suggests that *H. variegata* and *P. quatuordecimpunctata* may have failed to become established thus far in that location.

In several states, the survey participants periodically collected high numbers of the exotic coccinellids from host plants. For example, 187 *P. quatuordecimpunctata* adults were captured in 400 sweeps in Newport County, Rhode Island, in a 3-acre alfalfa field in July (L. Tewksbury, pers. commun.,

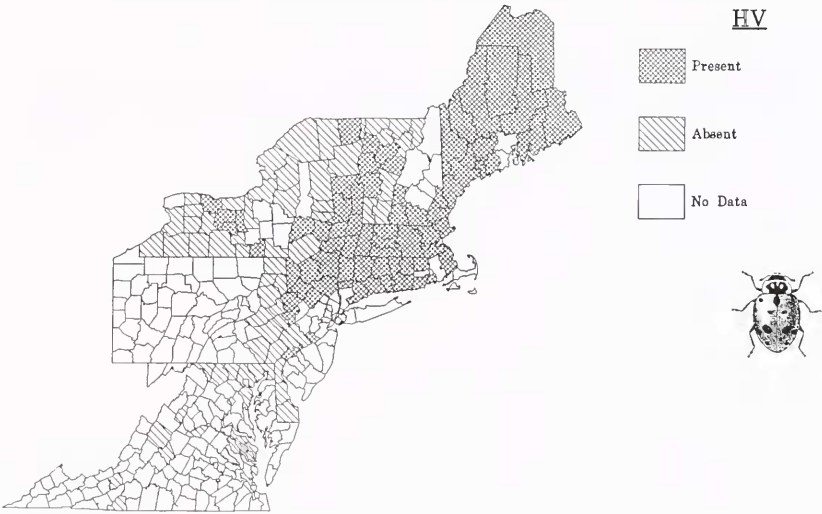


Figure 1. *Hippodamia variegata* (HV) distribution in the northeastern United States from 1984 to 1993. The map shows current distribution of HV and includes new state and county occurrences from the 1993 CAPS regional survey.

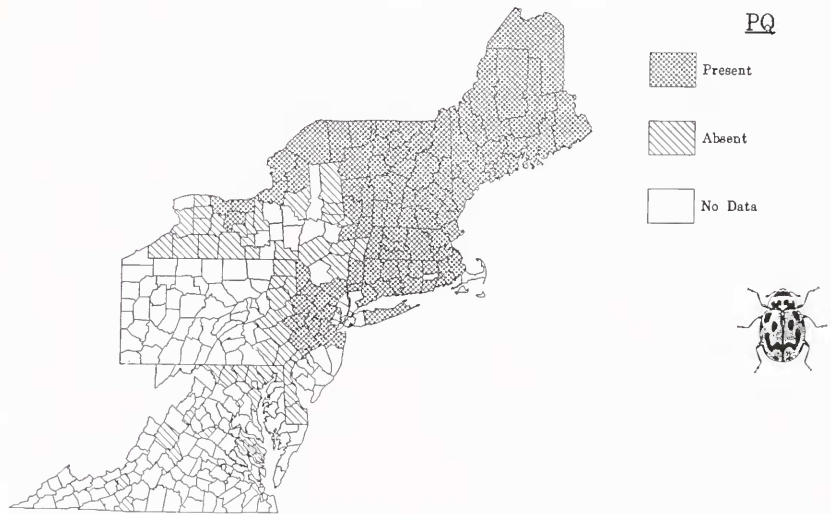


Figure 2. *Propylea quatuordecimpunctata* (PQ) distribution in the northeastern United States from 1984 to 1993. The map shows current distribution of PQ and includes new state and county occurrences from the 1993 CAPS regional survey.

[Note: Figs. 1 and 2: Counties are designated as "present" if the coccinellid was found in any year listed in the caption. Data include information from Dysart 1987; Dysart 1988; Wheeler 1993; Chianese (pers. commun., 1994); Day et al. 1994; and the NAPIS database, CAPS Program, USDA. Maps generated by D. Ellis, CAPS Program, on 6 January 1994.]

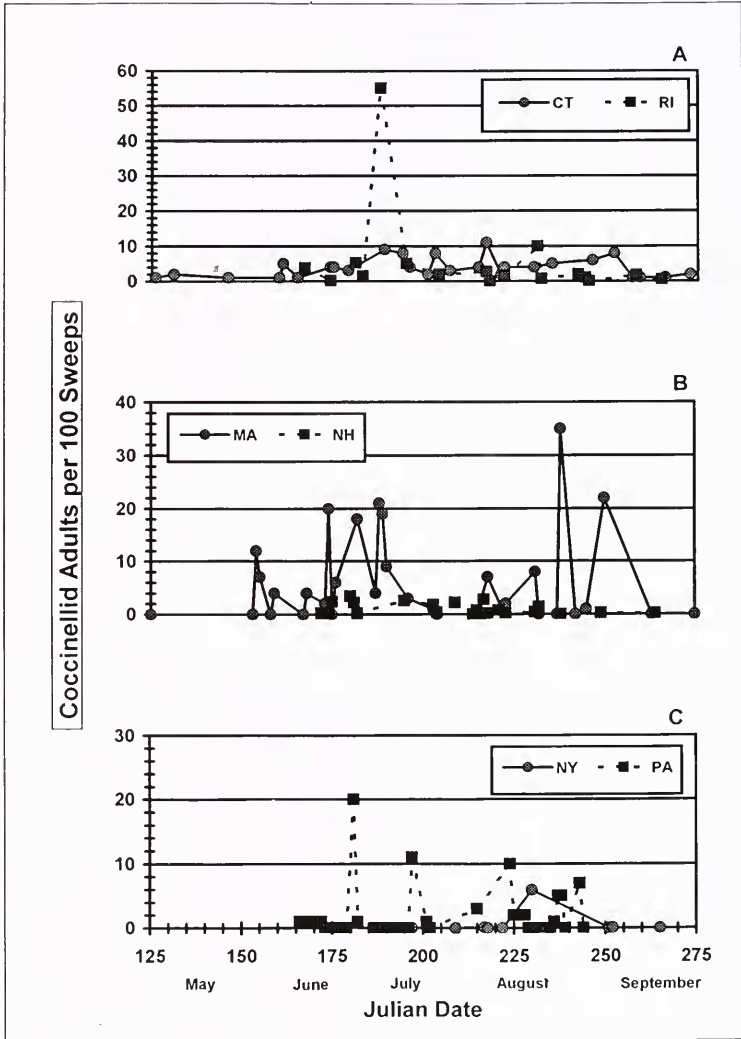
1993). In New Hampshire, 69 *H. variegata* adults were collected from 250 sweeps in an alfalfa field in September.

Several cooperators observed lower numbers of aphids on host plants during the hot, dry 1993 summer, likely resulting in lower coccinellid captures at some locations. For example, *P. quatuordecimpunctata* adults were common in Connecticut strawberry fields in late spring and were even found in fields where aphid populations were low but populations of twospotted spider mites, *Tetranychus urticae* Koch, were high. In general terms, aphids were not consistently found in high populations at all survey sites.

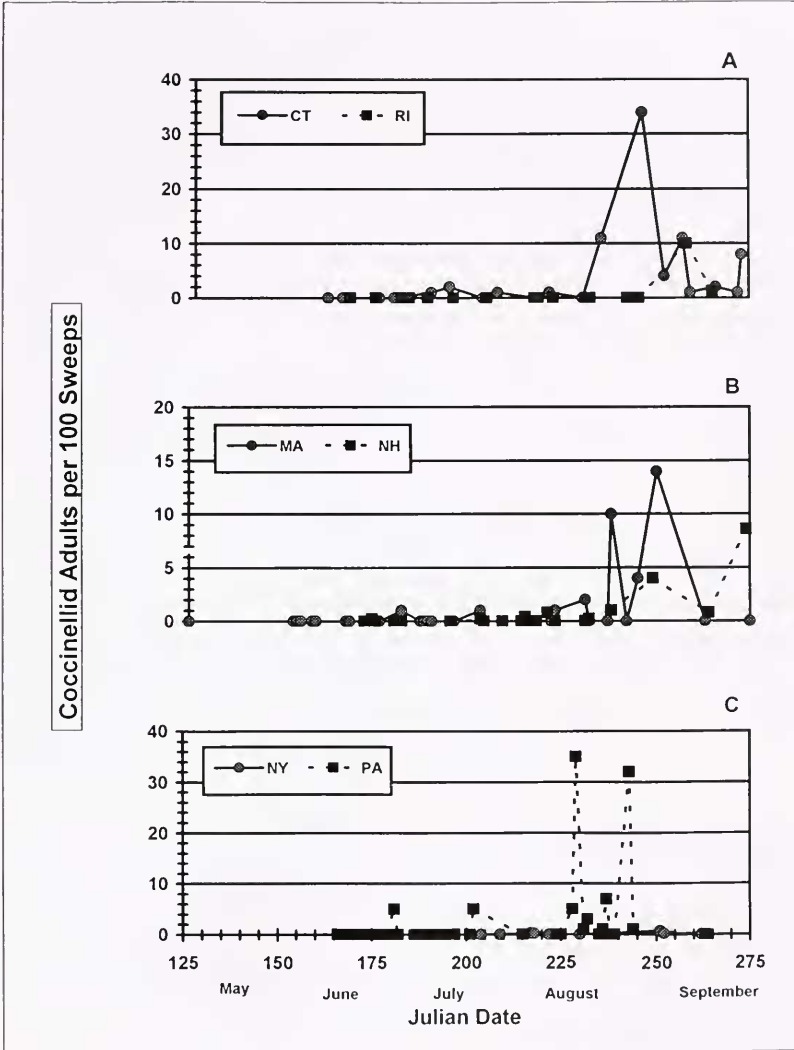
In the 11-state region, plant species that served as hosts for aphids, the preferred prey of the beneficial lady beetles, included agronomic crops such as alfalfa (*Medicago sativa* L.), clover (*Trifolium* spp.), rye (*Secale cereale* L.), and vetch (*Vicia* spp.), as well as many weed species, including Canada thistle [*Cirsium arvense* (L.) Scopoli], goldenrod (*Solidago* spp.), horseweed [*Conyza canadensis* (L.) Cronquist], and ragweed (*Ambrosia artemisiifolia* L.). Cooperators in several states observed *H. variegata* and *P. quatuordecimpunctata* adults on other host crops (e.g., apple, blueberries, broccoli, strawberries, and sweet corn) in addition to the crops recommended in the survey protocol. The coccinellids were observed on the crop or were captured on sticky traps placed within the crop canopy. In an apple orchard in New Haven County, Connecticut, 71 *P. quatuordecimpunctata* adults were captured on Ladd apple maggot traps between 23 June and 4 August 1993. During the previous year, 134 adults were captured on Ladd traps in the same orchard during a four-week period.

The diversity of host plants and habitats where *H. variegata* and *P. quatuordecimpunctata* were found during this survey might be a key to the successful establishment of these coccinellids in the northeast and the failure of the lady beetles to survive in major wheat-growing areas where Russian wheat aphids are found. Survey participants observed *H. variegata* and *P. quatuordecimpunctata* larvae and adults on weeds growing along the edge of crops that were periodically disturbed, such as an alfalfa field harvested for hay, and in weedy areas along roadsides. It is possible that weedy field borders, serving as alternative hosts for aphids, contribute to the survival of the coccinellids in areas where the primary host crop is disturbed. By contrast, the cultural and harvest practices used in the expansive wheat fields in the midwestern and western United States may negatively affect aphid numbers and habitat, leaving few alternative habitats for *H. variegata* and *P. quatuordecimpunctata*. In the northeast, weedy field borders or woodland edges surrounding the smaller fields of alfalfa and other crops may function as alternative habitats for lady beetles and aphids, providing host plants and areas for overwintering and reproduction when the crop is disturbed.

In addition to collecting *H. variegata* and *P. quatuordecimpunctata* adults during the multistate survey, cooperators recorded information on other beneficial coccinellids captured in sweep nets or observed in the field. A total of 17



Figures 3A-3C. Total daily sweep trap captures in Connecticut and Rhode Island (Fig. 3A), Massachusetts and New Hampshire (Fig. 3B), and New York and Pennsylvania (Fig. 3C) for *Propylea quatuordecimpunctata* (PQ) in 1993 (Note: each data point may represent a total of 1 to 12 samples taken on that day). Figures generated from NAPIS data).



Figures 4A-4C. Total daily sweep trap captures in Connecticut and Rhode Island (Fig. 4A), Massachusetts and New Hampshire (Fig. 4B), and New York and Pennsylvania (Fig. 4C) for *Hippodamia variegata* (HV) in 1993 (Note: each data point may represent a total of 1 to 8 samples taken on that day. Figures generated from NAPIS data).

coccinellid species were collected during the survey period, including other introduced coccinellids, such as *Coccinella septempunctata* L., the seven-spotted lady beetle, and native coccinellid species (Table 3). *C. septempunctata* was found in high numbers (e.g., up to 33 adults collected per 100 sweeps) at survey sites in the northeast during 1993. These results reveal the diversity of native and introduced beneficial coccinellids that are available for biological control of aphids and other plant pests.

Our survey results may provide additional data to document the displacement of native aphidophagous coccinellids by introduced species. For example, Wheeler (1993) and Wheeler and Hoebeke (1995) commented on the possible displacement of *Coccinella novemnotata* Herbst by the introduced *C. septempunctata* in the northeastern U.S. During this survey, the participants did not collect any *C. novemnotata* specimens. Similarly, Wheeler (1993) did not detect *C. novemnotata* at any of the 62 sites surveyed in the northeastern United States in September 1992 but collected 66 *C. septempunctata* adults at 23 sites during that period. Wheeler discussed variations in coccinellid abundance due to the time of year in which the survey was conducted.

We noted a similar trend for *Hippodamia convergens* Guerin. Survey participants detected this coccinellid in unusually low numbers during the survey period, recovering only two *H. convergens* from 29 Connecticut and Pennsylvania survey sites. In addition, 15 *H. convergens* adults were swept from host plants in Virginia from 9 June through 26 September 1993, in comparison with 426 *C. septempunctata* adults that were collected during the same time period. These results are consistent with those reported by Wheeler (1993), who collected 66 *C. septempunctata* adults but only one *H. convergens* during a 1992 survey. Overall, our results provide additional information to the coccinellid historical database for the northeastern United States, and we encourage other

Table 3. Native and introduced aphidophagous coccinellids collected in 11 states in the northeastern United States during 1993.

Native species

Adalia bipunctata (L.)
Anisosticta bitriangularis (Say)
Brachiacantha felina (F.)
Brachiacantha ursina (F.)
Calvia quatuordecimguttata (L.)
Chilocorus stigma (Say)
Coccinella trifasciata Mulsant
Coleomegilla maculata lengi Timberlake
Cycloneda munda (Say)
Hippodamia convergens Guerin
Hippodamia glacialis glacialis (F.)
Hippodamia parenthesis (Say)
Hyperaspis proba (Say)

Introduced species

Coccinella septempunctata L.
Harmonia axyridis (Pallas)
Hippodamia variegata (Goeze)
Propylea quatuordecimpunctata (L.)

researchers to continue investigating this area of study.

Results from the 1993 CAPS multistate survey, together with historical records beginning in 1984, document the establishment of *H. variegata* and *P. quatuordecimpunctata* throughout New England, in many northern and eastern counties in New York, in northern New Jersey, and in eastern Pennsylvania (NAPIS database, CAPS Program, USDA 1993, Wheeler 1993, Day et al. 1994, Wheeler and Stoops 1996). It seems that these beneficial coccinellids have become well established and have readily adapted to the many diverse habitats found in the northeastern United States. Day et al. (1994) attributed this successful establishment to the accidental introduction and natural dispersal of *H. variegata* and *P. quatuordecimpunctata* from Canada, rather than intentional releases.

The CAPS multistate survey has contributed significantly to the expanded knowledge base and current distribution of *H. variegata* and *P. quatuordecimpunctata* in the northeastern United States and has provided pertinent information on habitat requirements and preferences of these exotic coccinellids. These findings may help researchers better understand the conditions required for establishment of *H. variegata* and *P. quatuordecimpunctata* in regions where Russian wheat aphid biological control is needed. Future studies should address the distribution of *H. variegata* and *P. quatuordecimpunctata* populations as they expand into southern New York, western Pennsylvania, Ohio, and through New Jersey, Delaware, Maryland, and Virginia. Further research on habitats of exotic coccinellids may provide additional information on the ability of these species to: 1) further extend their current distribution in the northeast; and, 2) become established in western and midwestern states where the Russian wheat aphid occurs.

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